



Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Improving the Damage Resistance of Oxide Glasses from Knowledge of their Structural Response to Densification

Sir Alastair Pilkington Award Lecture

Smedskjær, Morten Mattrup

Publication date:
2018

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Smedskjær, M. M. (2018). *Improving the Damage Resistance of Oxide Glasses from Knowledge of their Structural Response to Densification: Sir Alastair Pilkington Award Lecture*. Abstract from 15th International Conference on Physics of Non-Crystalline Solids & 14th European Society of Glass Conference , Saint Malo, France.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- ? Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- ? You may not further distribute the material or use it for any profit-making activity or commercial gain
- ? You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Improving the Damage Resistance of Oxide Glasses from Knowledge of their Structural Response to Densification

Morten M. Smedskjaer

Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark

Increasing the hardness and crack resistance of oxide glasses is critical for the development of damage resistant and mechanically durable glasses for advanced applications. These properties can conventionally be measured using instrumented indentation (such as Vickers) that mimics the real-life damage for certain applications. Early indentation experiments have shown that oxide glasses exhibit pronounced tendency to densify under compressive load, in addition to elastic deformation and shear flow. The deformation mechanism affects the build-up of residual stress, and thus the driving force for cracking. Here, we discuss how knowledge of the deformation mechanism and the accompanying pressure/stress-induced structural transformations in the glassy network can be used to design crack resistant glasses. Our results show that high crack resistance can be associated with the ability of the glasses to self-adapt the connectivity of their network under compressive stress, which facilitates densification and thus aids in dissipation of the energy supplied during impact [1,2]. We have used this knowledge in the design of highly crack resistant aluminoborate glasses. In addition to lowering the driving force for cracking, the glass' resistance to cracking should also be considered, which is likely related to the bond constraint density. High-temperature densification can be used to increase the latter, but typically results in less densification during indentation and thus an increased driving force for cracking. However, by carefully tailoring the glass structure, we show that it is possible to use high-temperature densification to improve hardness and crack resistance simultaneously by avoiding the pressure-induced decrease in densification contribution to deformation [3]. Finally, we also show that the effect of pre-densification on hardness, crack resistance, and ion exchange strengthening characteristics depends on the utilized densification route (thermal vs. pressure) [4,5]. Overall the results suggest that understanding the structural response of oxide glasses to compression can be helpful for improving their damage resistance.

- [1] K. Januchta, R.E. Youngman, A. Goel, M. Bauchy, S.L. Logunov, S.J. Rzoska, M. Bockowski, L.R. Jensen, M.M. Smedskjaer, *Chem. Mater.* **29**, 5865-5876 (2017).
- [2] K.F. Frederiksen, K. Januchta, N. Mascaraque, R.E. Youngman, M. Bauchy, S.J. Rzoska, M. Bockowski, M.M. Smedskjaer, *J. Phys. Chem. B* **122**, 6287-6295 (2018).
- [3] S. Kapoor, K. Januchta, R.E. Youngman, X. Guo, J.C. Mauro, M. Bauchy, S.J. Rzoska, M. Bockowski, L.R. Jensen, M.M. Smedskjaer, *Phys. Rev. Mater.* **2**, 063603 (2018).
- [4] M.M. Smedskjaer, M. Bauchy, J.C. Mauro, S.J. Rzoska, M. Bockowski, *J. Chem. Phys.* **143**, 164505 (2015).
- [5] M.N. Svenson, L.M. Thirion, R.E. Youngman, J.C. Mauro, M. Bauchy, S.J. Rzoska, M. Bockowski, M.M. Smedskjaer, *Front. Mater.* **3**, 14 (2016).